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EXHAUST MANIFOLD OF INTERNAL-COMBUSTION ENGINE JP S60-187712

What is claimed is:

An exhaust manifold of internal-combustion engine wherein the main body of the exhaust manifold has double-layered structure comprises,

an inner pipe unit wherein an inner layer of said inner pipe, which faces to emission gas, is made of hard ceramic and an outer layer of said inner pipe, which surrounds said inner layer, is made of soft ceramic, and

an aluminum outer pipe unit wherein said outer pipe unit is integrally molding (and covering) said inner pipe unit from outside.

Detailed Description of the Invention

(Technical field)

The present invention is related to an exhaust manifold of internal-combustion engine.

(Background of the invention and Prior Art)

It is well known that exhaust manifolds (multiple exhaust cylinders) are often installed in automobiles as they are connected to each cylinder in multicylindered internal-combustion engine. It is also well known that the structure of the exhaust manifold is often designed so as to avoid adverse influence of heat in forging and running engine or to save weight. For example, conventional exhaust manifolds are described in Japanese utility model application No. S56-37047 and Japanese utility model publication No. S57-47713. The exhaust manifold in the latter example (Japanese utility model publication) is shown in Figs. 1(A) and (B).

The main body of the exhaust manifold 1 has a double-layered pipe unit comprises an inner pipe unit 2 molding the solid ceramic material into multiple cylinders, and cast-iron outer pipe unit 2 wherein the outer pipe unit is integrally molded with the inner pipe unit. The exhaust manifold is divided into three parts A, B and C, and those three parts are lined column-wise to cylinders (tripartition structure).

Using the above-mentioned ceramic material drastically saves weight of the part (conventionally) made of heavy cast-iron, and saves the (total) weight of the exhaust manifold.

At the same time, heat stress and vibration to the inner pipe unit 2 caused by driving or stopping engine and thermal shock caused by molding the main body of the exhaust manifold are reduced by introducing the above mentioned tripartition structure. In other words, because the inner pipe unit 2 is made of inflexible solid ceramic material and the outer pipe unit 3 is made of cast-iron, which has a high melting point (the liquid temperature for forging cast-iron is from 1,500 to 1,600 ℃), the damage to the inner pipe unit 2 caused by the thermal shock in manufacturing the main body of the exhaust manifold, and the heat stress caused by the difference of thermal expansion coefficient between the inner pipe unit 2 and the outer pipe unit 3 in running engine are prevented by the tripartition structure.

However, in the conventional exhaust manifold of internal-combustion engine, number of parts, man-hour and cost are increased because the exhaust manifold is designed to have tripartition structure in the longitudinal direction to avoid adverse influence of heat.

Further, because the solid ceramic, which is forming the inner pipe unit 2, has low porosity and has insufficient insulation, temperature of the outer pipe unit 3 tend to be high and only heat- resistant materials can be used for the outer pipe unit 3. This is one of the factors, which obstructs drastic weight saving by introducing right materials, such as aluminum.

(Purpose of the invention)

This invention is made especially focusing on solving the above-mentioned problems. The purpose of the invention is to increase its durability and to save weight by introducing unitary construction and using aluminum.

(Disclosure of the invention)

In the present invention, in the multicylindered internal-combustion engine for automobiles, the two layered exhaust manifold comprises an inner pipe unit wherein an inner layer of the inner pipe, which faces to emission gas, is made of hard ceramic and an outer layer of the inner pipe, which surrounds the inner layer, is made of soft ceramic, and an aluminum outer pipe unit wherein the outer pipe unit is integrally molding (and covering) the inner pipe unit from outside.

In the present invention, because high temperature exhaust heat is insulated by the inner pipe unit, which is made of ceramic fiber and has low heat conductance, the outer pipe unit may be made of aluminum material, which has low melting point.

The outer layer of the inner pipe unit made of ceramic fiber is much more flexible than the (conventional pipe) made of solid ceramic, and as mentioned above, aluminum material has much lower melting point than cast-iron. (the liquid temperature for forging aluminum material is around 700 ℃). Therefore the inner pipe unit suffers very little heat stress in forging and less heat stress in running and stopping engine. It also makes it possible to form the exhaust manifold into unitary construction and reduces cost. Moreover, because the inner layer of the inner pipe is made of hard ceramic, it prevents flaking of fibers, and improves durability.

(Embodiments)

The first embodiment of the present invention is described referring to the drawings. As shown in Figs 2(A), (B) and (C), all cylinders (total six cylinders) of the main body of the exhaust manifold 10 is unitary constructed.

A main body of the exhaust manifold 10 has a two layered structure comprises an inner pipe unit 11 and an outer pipe unit 12. And the inner pipe 11 has a two layered structure comprises an inner layer 11A and an outer layer 11B.

The above mentioned inner pipe unit 11 is made of ceramic fiber and is molded into multiple cylinders, and the outer pipe unit 12 is made of aluminum wherein the outer pipe unit 11 is integrally molded with the inner pipe unit.

The ceramic fiber materials available for the inner pipe unit 11 are silica alumina fiber, alumina fiber and silica fiber and so on. Especially the materials having high rigidity and hardness are used for the inner layer 11A, which faces emission gas, and the materials having flexibility and softness are used for the outer layer 11B.

Example characteristics of the materials are shown in the following table.

Item	Inner layer	Outer layer
Bulk density	0.2~0.7 gram/cm^3	0.06~0.2 gram/cm^3
Melting point	1800℃	Same as on the left
Bend strength	5~15 kg/cm^2	5 kg/cm^2
Component		
Al_2O_3	40~60%(weight)	Same as on the left
SiO_2	60~40%(weight)	Same as on the left

Either wet lamination or vacuum forming is adopted to produce halved or entire unit of the inner layer 11A.

Wet lamination is a casting method in which the several thin ceramic fiber sheets absorbing the binder, such as silica solution are layered.

Vacuum forming is a casting method in which the (shaped) wire fabric is soaked into the solution including floating ceramic fiber and then vacuumed.

(Casting the inner pipe by) the vacuum forming has an advantage in that the surface facing to the wire fabric, more specifically the surface facing to emission gas, has high density, has high resistance to emission gas, and prevents flaking of the fiber.

On the other hand, half unit of the outer layer 11B is formed by pressing ceramic fiber, glued on the outer surface of the inner layer 11A using glue, such as silica sol, and united with the inner layer 11A.

In the present invention, aluminum liquid is used for forging the main body of the exhaust manifold (the outer pipe unit 12). Because the temperature of the aluminum liquid is around 700℃ and considerably lower than conventional forging liquids, difference of temperatures of the outer pipe unit 12 and the inner pipe unit 11 is reduced by half. Moreover, because the outer layer 11B, which is facing to the aluminum material, is made of ceramic fiber, which is considerably more flexible than conventional solid ceramics, the heat stress to the inner layer 11A, which is relatively hard, is reduced, and the damage to the total inner pipe unit 11 can be avoided. Moreover, unitary construction in the present invention makes it possible to reduce number of parts, man-hour and cost for manufacturing and assembly. At the same time, the outer layer 11B of the inner pipe unit 11 absorbs heat and difference of expansivity between the inner pipe unit 11and the outer pipe unit 12 by running and stopping engine, reduces heat stress to the aluminum outer pipe unit and improves durability.

Following table shows the difference of temperature limits to protect against the failures caused by thermal shock to the popular solid ceramics.

Name of material	Temperature limit
Silicon nitride (Si_3N_4)	500℃
Silicon carbide (SiC)	280℃
Zirconia (ZrO_2)	260℃
Ceramic fiber	Higher than 1000℃

In the present invention, because the inner pipe unit 11 is made of ceramic fiber and its thermal conductivity is lower than conventional solid ceramics, the emission gas is not cooled down, and the gas cleanup efficiency by a catalytic substance, which is placed in the emission, is increased. On the other hand, because the ceramic fiber prevent the rise of temperature, it also

makes it possible to use aluminum materials, which have low melting point, for the outer pipe unit 12.

Meanwhile, following tables show the thermal conductivity of ceramics and air, as a control, and the difference of the temperature of interface between the inner pipe unit 11 and the outer pipe unit 12 in the main body of the exhaust manifold when an engine is running under very high load conditions. (temperature of the emission gas is from 750 to 850℃) .

Name of material	Thermal conductivity *
Silicon nitride (Si_3N_4)	0.037
Silicon carbide (SiC)	0.158
Ceramic fiber	0.0001
Air	0.00006

(*unit: calorie/cm·sec·℃)

Spec	Temperature of intersurface
The present invention (Ceramic fiber)	250~350℃
Conventional (Solid ceramic)	550~650℃

Because aluminum material is available for the outer pipe unit 12, the weight of the main body of the exhaust manifold is drastically saved compared to the one made of iron-cast in conventional examples, and the total weight of the engine is also reduced.

(Effect of the invention)

In the present invention, the inner layer of the inner pipe unit, which is facing to emission gas is made of hard ceramic fiber, the outer layer of the inner pipe unit is made of soft ceramic fiber and integrally molding the inner layer. The aluminum outer pipe unit is cast around the inner pipe unit. This structure reduces heat stress to the inner pipe unit in forging, makes unitary construction available, reduces man-power and cost in manufacturing and assembly, and drastically saves weight.

Moreover, the inner layer of the inner pipe unit is made of hard material and receives less damage from contact with emission gas. The outer layer of the inner pipe unit is made of soft material, absorbs heat and difference of expansivity between the inner pipe unit and the outer pipe unit, avoid excessive amount of heat stress to the aluminum outer pipe unit, and improves durability.

(Brief explanation of the drawing)
Fig. 1 (A) is a front view of an example of conventional exhaust manifolds.
Fig. 1 (B) is a cross-sectional view of the same taken along the line I-I.
Fig. 2 (A) is a front view of the first embodiment of the present invention.
Fig. 2 (B) is a cross-sectional view of the same taken along the line II-II.
Fig. 2 (C) is a cross-sectional view of the same taken along the line III-III.
Fig. 3 is a cross-sectional view of the second embodiment of the present invention taken along the same line as Fig. 2 (C).

10: main body of exhaust manifold
11: inner pipe unit
12: outer pipe unit
13: coating layer